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ABSTRACT

Scores on mental ability and academic skills for 1958 and 1978 of representative sample of grade 4 and 7 classes in Saskatchewan were compared. The selected students were administered appropriate levels of the Otis-Lennon Mental Ability Tests, and the Canadian Tests of Basic skills in vocabulary, reading, language skills (spelling, capitalization, punctuation, and usage), and mathematics skills (concepts and problem solving). Results indicated that the mental ability of children has substantially improved, and that in academic skills the performance in 1978 is at least equivalent to that in 1958. Factor analyses of the grade 4 and 7 intercorrelation matrices produced in each case only one principal factor which suggests that the underlying ability necessary for the various academic and ability tasks is similar. The kind of score analysis necessary for determining the status of basic skills should not be the total score analysis, but a skill profile analysis. For a meaningful skill profile comparison to emerge, it is necessary that the learning criteria of the skills for the two points in time are known precisely. This was not the case in this study. (Author/RL)

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Change in Intelligence and Academic Skills of Grades Four and Seven Pupils over a Twenty-Year Period

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Paper presented at the 22nd International Congress of Psychology, Leipzig, German Democratic Republic, July 6-12, 1980.

Abstract

Comparisons of scores on mental ability and academic skills for 1958 and 1978 of representative samples of grade four and seven classes in Saskatchewan indicate that the mental ability of children has substantially improved and that in academic skills generally the performance in 1978 is at least equivalent to that in 1958. Factor analyses of the grade four and seven intercorrelation matrices produced in each case only one principal factor which suggests that the underlying ability necessary for the various academic and ability tasks is similar. Suggestions for a meaningful analysis and interpretation of change score data are provided.

Change in Intelligence and Academic Skills of Grades Four and Seven Pupils over a Twenty-Year Period

Interest in the level of ability and academic competence of students in our educational institutions at present as compared with their counterparts of several years ago has never been as high as in the last decade or so. This is evident from the large number of "then and now" studies recently completed in Canada and other countries. The unusual interest in the change, if any, of academic achievement and ability is not a recent phenomenon. Boss (1940) did a "then and now" study in Reading and Sligo (1955) compared achievement in selected high school subjects in 1934 with that in 1954.

It is reasonable to assume that from time to time pressures are perceived by politicians and administrators to demonstrate that the present academic and ability levels of children in their jurisdictions are as high as that of similar students in the past. Such pressures usually begin with the assumption that the "good old times" were much better than the present. A natural reaction to such pressures is to gather and present evidence on the present status of cognitive and academic ability. The vehicle for such evidence is usually a "then and now" study which involves testing a present group of students which can be matched to a previously tested group. The same or equivalent tests are administered to the present group of students within the equivalent testing period. Such testing and the use of the test results is based on a number of assumptions and the results are generally not unequivocally interpretable. Nevertheless, many assessment projects have already been completed in Canada (Clark, Nyberg, & Worth, 1977; Hedges, 1977; Newfoundland and Labrador Department of Education, 1975, 1976, 1977, 1978; Nova Scotia Department of Education, 1976, 1978). The impetus for the present study in Saskatchewan came from the studies already

carried out in other provinces as well as local political pressures.

In Saskatchewan a study of achievement and ability status was made of grades four to eight in 1958. The subjects were selected on the basis of a 15% stratified random representation of classrooms in the province in various grades. The present study was undertaken to determine whether scores in intelligence and academic skills in 1958 and 1978 were equivalent and whether norms of the tests used were equivalent to the 1978 Saskatchewan norms. Also, the 1978 data were used to establish an academic skills construct.

Method

Approximately 10% of the classrooms of grades four and seven were randomly selected from each school jurisdiction in the province in 1978. The selected classrooms were administered the appropriate levels of the Otis-Lennon Mental Ability Tests, and the Canadian Tests of Basic Skills in Vocabulary, Reading, Language Skills, consisting of Spelling, Capitalization, Punctuation, and Usuage, and Mathematics Skills, consisting of Mathematics Concepts and Mathematics Problem Solving.

Results

Mental Ability. -- A brief description of the samples in terms of number, age, and deviation IQ is given in Table 1. It should be noted that in terms of

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Insert Table 1 about here.
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the Otis-Lennon deviation IQ norms, the Saskatchewan samples were significantly above the mean of the standardization sample. The comparative status of grade four pupils for the two years is provided in Table 2. It is clearly evident that

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Insert Table 2 about here.
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the grade four pupils, in terms of the Otis-Lennon raw score, achieved significantly higher than their counterparts in 1958. Also in terms of raw score, the conclusion from the results in Table 1, that the Saskatchewan sample is significantly above the average of the standardization sample, is further confirmed. However, as indicated in Table 2, the raw score status of grade seven pupils for 1958 was not available. Hence, the comparison for the two years in terms of raw scores is not possible. A comparative standing of grade four and seven for the two years in terms of the deviation IQ scores on the Otis-Lennon test is reported in Table 3. It is quite clear that the 1978 scores for these two

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Insert Table 3 about here.
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grades were substantially and significantly higher in 1978 than in 1958. As is noted in the footnote, the equivalent Otis-Lennon DIQ's for both grades four and seven were obtained by converting the mid-points of the frequency distributions to the equivalent Otis-Lennon DIQ's. So there may be a small error due to grouping of the 1958 data. However, it is hard to determine the direction of the error. Even with this sort of grouping error, the difference is large enough to conclude that the mental ability of children in 1978 was substantially better than in 1958. This conclusion is consistent with the data for Alberta (Clarke, Nyberg, & Worth, 1977), as well as the norming data available for several mental ability tests on the market.

Achievement. -- The raw score statistics of grade four students in the 1978 Saskatchewan sample and the 1973 standardization sample on the CTBS (Form 4M) are given in Table 4. It is generally clear that the mean of the raw

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Insert Table 4 about here.
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scores of the Saskatchewan sample was significantly better than the standardi-

zation sample in all the subtests of the CTBS except the Language Usage. However, in Language Usage, the raw score average was still slightly higher than that of the standardization sample. It is evident from the results in Table 4 that the differences in variances of grade four samples were significant in all the tests except the Mathematics Skills total, and that these differences in variances were such that the Saskatchewan sample had a larger variance in Reading, Capitalization, and Punctuation whereas on the other tests the standardization sample had the larger variance. The larger variance in the standardization sample is to be expected due to the sampling scope and the diversities of the regions in the country included in the standardization sample. However, the larger variance in the Saskatchewan sample in Reading, Capitalization, and Punctuation indicates that the diversity in scores in Saskatchewan on these tests is even larger than that in the national sample. The reliability and standard error of measurement values for the two samples seem to be quite comparable.

The raw score statistics for grade seven students in the 1978 Saskatchewan sample and the 1973 national standardization sample on the CTBS (Form 4M) are provided in Table 5. As indicated in Table 5, the Saskatchewan sample of grade

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Insert Table 5 about here.

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seven students achieved significantly better than the national standardization sample in all the subtests of the CTBS except Spelling and Language Usage. In Spelling and Language Usage, the two samples were statistically equivalent in terms of mean achievement. The variances of the two groups were such that the Saskatchewan sample had larger variance in Vocabulary, Capitalization and Total Language and in all the other subtests the national standardization sample, as expected, had larger variance. Again the reliability and the standard error of measurement of the two samples were quite comparable.

Comparisons of the Language and Mathematics skills of the grade four sample for 1958 and 1978 are provided in Table 6. In terms of overall Language and Mathe-

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Insert Table 6 about here.
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matics skills, the 1978 sample achieved significantly better than the 1958 sample. However, in terms of the specific subtests in these areas, the 1978 group achieved significantly better in Spelling, Punctuation, and in both the subtests in Mathematics, whereas the 1958 sample had substantially better academic skills level in Capitalization and Language Usage as compared with the 1978 sample. It must be noted, however, that the 1958 grade equivalents were reported in group frequencies and the reported means and standard deviations are therefore only approximate. Also, the Mathematics Basic Concepts subtests used in 1978 appear to have evolved from the old Iowa Every-Pupil Tests of Basic Skills (IETBS) in Vocabulary and Fundamental Knowledge, and Fundamental Operations. The 1973 edition of the CTBS does not have the Sentence Sense subtest in Language skills as was the case with the IETBS. The comparison in achievement in Language and Mathematics skills for the Saskatchewan samples in 1978 and 1958 needs to be qualified as there was no direct equivalence link available between the CTBS used in 1978 and the IETBS used in 1958. The basis for converting the IETBS Language and Mathematics scores into the equivalent CTBS scores was computational and extrapolational using the Iowa data from 1955 to 1977 on the Iowa Test of Basic Skills. However, a conservative inference can be made that the 1978 overall Language and Mathematics skills in the province of Saskatchewan were at least equivalent to the 1958 overall achievement.

The grade seven grade equivalents of the 1958 results on the IETBS and the 1978 results on the CTBS are reported in Table 7. It is evident that the

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Insert Table 7 about here.

1978 sample had a significantly better standing in the overall Language and Mathematics skills than the 1958 sample. However, the 1978 sample achieved significantly better in Spelling, Capitalization, Punctuation and Mathematics Basic Concepts and Problems than the 1958 sample. In the Language Usage subtest, the 1978 sample did not achieve as well as the 1958 sample. These results must also be interpreted in terms of the reservations mentioned above for grade four comparisons.

Academic Skills Construct. -- Correlations among tests, their reliabilities, reliabilities of difference scores, communalities, and principal factor loadings for grade four and seven Saskatchewan samples are given in Tables 8 and 9 respec-

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Insert Table 8 about here.
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tively. All of the test score intercorrelations for grades four and seven are

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Insert Table 9 about here.
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significant ($p<.05$). In grade four the lowest correlation (.475) was between Spelling and Math Problems and the highest was between the Otis-Lennon and the CTBS Reading (.758). Similarly, the lowest correlation of .477 and the highest correlation of .805 were obtained for the grade seven sample. When these two correlation matrices were factor analyzed in each case one principal common factor was obtained and this factor accounted for 61.6% and 64.2% of the variance in tests of grade four and seven respectively. This suggests that the underlying cognitive abilities and strategies appropriate for these basic skills and abilities were substantially similar. The nature of these abilities and strategies is not explicit from the analyses reported. An approach to understanding and training of these fundamental abilities may lie in the proposal contained in Sternberg (1977).

General Discusssion

Evidence on score trends between the mid-sixties and mid-seventies for

several tests in the United States are contained in a number of sources (See Marland, 1977; Harnischfeger & Wiley, 1975; Silver, 1977). It is clear from an examination of these results that a trend is dependent on several factors including: 1) the test score; 2) the subject/area, and 3) the population composition. Similar conclusions seem to be appropriate to the limited data available on the Canadian scene and particularly the Saskatchewan data. Some tests show decline, some show gain and some show no change.

If a test score trend shows no change or increase, this fact attracts perhaps little or no attention and debate. On the other hand, the observed decline on any major test becomes a hotly debated and discussed issue.

Given the attention, particularly in the United States, the "declining test score" phenonemon has drawn in the media, and its appearance in school board agendas, election campaigns, and technically any other debate of public education, the issue has been rather difficult to ignore. On the other hand, this issue is extremely difficult to understand and apparently there is no consensus on the reasons for the decline even after the evidence for the various different viewpoints has been presented and discussed (Silver, 1976). These differences are further magnified by the rather inaccessible and fragmented nature of the literature on the subject.

Perhaps no other test has received as much systematic study and passionate and deliberate discussion as the Scholastic Aptitude Test (SAT) (Nairn & Associates, 1980). A report of the Advisory Panel on the SAT Score Decline (Marland, 1977) pointed out that a major part of the decline in SAT, especially in its earlier stages after 1963 was "clearly traceable to a change in the composition of the student group taking the test" (p. 1). The Advisory Panel also concluded that the score change clearly reflected, particularly in the 1970's, "the operation of other more pervasive forces" (p. 1) in that "the score decline has not resulted from changes in the testing instrument" (p. 10). This Panel

also suggested that "in the 36 years since the present SAT standard was established the society has set new and different (as distinguished from higher or lower) learning goals, that the colleges or schools or both have adopted new priorities in Education, that different learning and communication processes have come into use, and that part of the reason for the decline in the SAT averages is that the test does not reflect these changes" (p. 10). This Advisory Panel was also concerned about the relationship between traditional testing techniques and the introduction into the teaching and learning process of new forms of communication and instruments such as tape recorders, films, film strips, television, and the like.

It appears from the published literature (Marland, 1977; Harnischfeger & Wiley, 1975; Silver, 1976) that score changes have been largest at the 12th grade level and somewhat less at each successively lower grade, with the score averages at grades one to four remaining virtually constant. This is somewhat consistent with our results presented above. A variety of explanations for this score change phenonemon have been advanced, but most of these have been made without any systematic and analytic data. Some of these are: decreasing effectiveness of school systems at the upper elementary and secondary grades, increasing school retention rates, changing motivational factors, possible diminishing relevance of the standardized tests to what is being taught in schools, increasing curriculum diversity, changes in culture, changes in attitude of students toward testing, changes in college admission policies, and failure of public schools to teach basics. In the context of such reasons for score change or no change, whatever actions may be proposed those would certainly have significant political ramifications. The important considerations should not necessarily be to arrest the score decline or to stimulate gain, but to determine whether the societal mandate is being met by the existing school systems. If the basic skills which were considered important some years ago are not important for our society today,

then a decline in score on those skills is to be expected. However, if the score decline occurred in some skills which are regarded as fundamentally crucial even today, then the obvious conclusion is that the school system has not met the societal expectations.

The kind of score analysis necessary for determining the status of fundamental skills should not be the total score analysis but a skill profile analysis. For a meaningful skill profile comparison to emerge, it is necessary that the learning criteria of the skills for the two points in time are precisely known. The decline, gain, or no change in score on a test over time is meaningless in itself unless the learning criteria of the various skills included on that test are known for the two time periods. As can be seen from the results given in this paper, this was not the case in Saskatchewan. The reason that we cannot adequately respond to "so what" is essentially the lack of meaningfulness in the comparisons reported (Traub, Wolfe, & Russell, 1976-77). However, it is fundamentally important to know what the nature of the criteria is and how the necessary academic skills can be taught in order to achieve these meaningful criteria. It is hoped that future research can provide answers to some of these fundamentally important issues.

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Table 1

Summary Statistics of Age and Otis-Lennon Deviation IQ's of Grades Four and Seven Saskatchewan Sample in 1978

Grade	N	Age (Months)			Deviation IQ		
		Mean	Median	S.D.	Mean	Median	S.D.
4	1410	114.3	113.3	7.2	107.6	108.4	14.8
7	1564	151.1	149.5	8.3	106.5	106.2	13.8

TABLE 2

Otis-Lennon (Form J) Raw Score Statistics for Grades Four and Seven

Grade	Test	1958[a]			1978				Standardization (October, 1966)			
		Mean	S.D.	N	Mean	S.D.	N	KR-20	Mean	S.D.	N	KR-20
4	Elementary II	34.12	13.81	3,002	40.43	13.31	1,410	.92	34.05	14.25	13,887	.93
7	Intermediate[b]	-	-	-	43.58	13.68	1,564	.92	37.46	15.72	13,808	.94

[a] The statistics reported here have been computed from the grouped frequency distribution available on the Otis Quick Scoring, Beta, Form A after converting the midpoints of the intervals to the corresponding score of the Otis-Lennon Mental Ability Test, Elementary II.

[b] The 1958 report did not provide the raw score distribution for grade 7.

TABLE 3

Otis-Lennon (Form J) Deviation IQ Statistics for Grades Four and Seven in 1958[a] and 1978

Statistic	Grade 4		Grade 7	
	1958	1978	1958	1978
Mean	95.05	107.6	99.55	106.5
Median	94.88	108.4	99.04	106.2
S.D.	13.57	14.8	12.64	13.8
N	2 942	1 410	2 316	1 564

[a] The reported values for 1958 have been derived from the Otis-Quick Scoring DIQ grouped frequency Tables in the 1958 report after converting the midpoints to the equivalent Otis-Lennon DIQ's according to Table 54 in the Technical Handbook for the Otis-Lennon Mental Ability Test.

Table 4

Comparison of Raw Score Statistics of Grade Four Students in the 1978 Saskatchewan Sample and the 1973 Standardization Sample on the CTBS (Form 4M)

Statistic	Sample	Vocabulary V	Reading R	Language Skills					Mathematics Skills		
				Spelling L-1	Capitalization L-2	Punctuation L-3	Usage L-4	Total	Concepts M-1	Problems M-2	Total M
Mean	Saskatchewan	19.9*	36.7*	21.5*	18.3*	17.3*	15.8	73.2*	18.4*	12.8*	31.2*
	Complete Standardization	17.4	28.1	18.0	16.3	14.4	15.5	64.4	16.6	11.6	28.2
S.D.	Saskatchewan	6.40	12.60*	7.70	6.74*	7.11*	6.12	23.26	6.19	5.01	10.43
	Complete Standardization	7.80*	11.77	8.54*	6.30	6.04	6.88*	23.72*	6.41*	5.16*	11.38
Reliability[a]	Saskatchewan	.85	.93	.89	.85	.85	.85	.94	.84	.80	.87
	Complete Standardization	.88	.92	.90	.84	.83	.89	.95	.82	.81	.90
Standard Error of Measurement	Saskatchewan	2.5	3.3	2.6	2.6	2.8	2.4	5.7	2.5	2.2	3.8
	Complete Standardization	2.8	3.6	2.7	2.6	2.6	2.3	5.2	2.7	2.3	3.6

[a] For the Saskatchewan sample the reported reliability is estimated using KR-20 formula whereas the representative standardization sample reliability is estimated using the split-half method.

* The designated mean or the variance corresponding to the designated S.D. is significantly greater than its counterpart beyond the .05 level.

Table 5

Comparison of Raw Score Statistics of Grade Seven Students in the 1978 Saskatchewan Sample and the 1973 Standardization Sample on the CTBS (Form 4M)

Statistic	Sample	Vocabulary	Reading	Language Skills					Mathematics Skills		
				Spelling	Capitalization	Punctuation	Usage	Total	Concepts	Problems	Total
		V	R	L-1	L-2	L-3	L-4	L	M-1	M-2	M
Mean	Saskatchewan	24.4*	40.3*	21.3	22.4*	20.2*	15.2	79.0*	23.9*	13.6*	37.3*
	Complete Standardization	22.6	38.4	21.0	20.0	17.9	15.4	74.4	22.7	13.3	36.0
S.D.	Saskatchewan	8.19*	13.48	9.31	7.52*	7.57	5.41	26.02*	7.94	4.85	11.94
	Complete Standardization	8.10	13.87*	9.66*	7.38	6.54*	5.82*	25.52	8.27*	5.62*	13.64*
Reliability[a]	Saskatchewan	.86	.92	.88	.85	.85	.78	.94	.86	.74	.87
	Complete Standardization	.86	.91	.91	.83	.80	.81	.95	.86	.79	.90
Standard Error of Measurement	Saskatchewan	3.1	3.8	3.2	2.9	2.9	2.5	6.4	3.0	2.5	4.3
	Representative Standardization	3.0	4.2	2.8	3.0	2.8	2.5	5.6	3.0	2.5	4.2

[a] For the Saskatchewan sample the reported reliability is estimated using KR-20 formula whereas the representative standardization sample reliability is estimated using the split-half method.

* The designated mean or the variance corresponding to the designated S.D. is significantly greater than its counterpart beyond the .05 level.

TABLE 6

Grade Four Grade Equivalents[a] of the 1958 Results on the Iowa Every-Pupil Tests of Basic Skills (Form L) and the 1978 Results on the Canadian Tests of Basic Skills (Form 4M)

Test	1958					1978				
	Number of Items	Time (Minutes)	Number of Students	Mean	S.D.	Number of Items	Time (Minutes)	Number of Students	Mean	S.D.
Language Skills:										
1. Spelling	40	8	3 018	45	14	38	12	1 375	47	12
2. Capitalization	40	8	3 108	49	16	39	15	1 377	45	13
3. Punctuation	35	11	3 018	40	13	39	20	1 377	47	13
4. Usage	40	13	3 018	54	20	32	20	1 370	46	13
5. Sentence Sense	35	6	3 018	45	21	-	-	-	-	-
Total L	190	46	3 018	45	12	148	67	1 365	46	11
Mathematics Skills:										
1. Vocabulary and Fundamental Knowledge	27	12	2 994	47	10	→ 36[b]	30	1 375	45	9
2. Fundamental Operations	35	20	2 994	40	6					
3. Problems	22	25	2 994	43	9	27	30	1 374	46	9
Total M	84	67	2 994	43	7	63	60	1 373	46	8

[a] 1958 GE's were reported in grouped frequencies. Therefore, the computed mean and S.D. are approximate.

[b] The test content of the Vocabulary and Fundamental Knowledge, and Whole Numbers and Fractions of the Iowa Every-Pupil Tests of Basic Skills and Mathematics Skills seems to be similar to the successor subtest Mathematics Basic Concepts in the CTBS. The data for 1978 is for the Mathematics Basic Concepts.

TABLE 7

Grade Seven Grade Equivalents[a] *of the 1958 Results on the Iowa Every-Pupil Tests of Basic Skills (Form L) and the 1978 Results on the CTBS (Form 4M)*

Test	1958					1978				
	Number of Items	Time (Minutes)	Number of Students	Mean	S.D.	Number of Items	Time (Minutes)	Number of Students	Mean	S.D.
Language Skills:										
1. Spelling	51	12	2 277	72	13	48	12	1 563	78	17
2. Capitalization	87	11	2 277	73	18	43	15	1 561	77	15
3. Punctuation	76	14	2 277	75	17	43	20	1 560	76	16
4. Usage	82	18	2 277	76	18	32	20	1 558	75	16
Total L	296	55	2 277	75	14	166	77	1 558	77	14
Mathematics Skills:										
1. Vocabulary and Fundamental Knowledge	40	15	2 213	75	12	→ 48[b]	30	1 553	77	13
2. Whole Numbers and Fractions	43	30	2 213	73	10					
3. Problems	25	18	2 213	74	15	32	30	1 556	76	13
Total M	108	63	2 213	74	11	80	60	1 553	76	12

[a] *1958 GE's were reported in grouped frequencies. Therefore, the computed mean and S.D. are approximate.*

[b] *The test content of the Vocabulary and Fundamental Knowledge, and Whole Numbers and Fractions of the Iowa Every-Pupil Tests of Basic Skills in Mathematics Skills seems to be similar to the successor subtest Mathematics Basic Concepts in the CTBS. The data for 1978 is for the Mathematics Basic Concepts.*

Table 8

Correlations among Tests, Reliabilities, Reliabilities of Difference Scores, Communalities and Factor-Loadings for Grade Four Saskatchewan Sample in 1978[a,b]

Tests	1	2	3	4	5	6	7	8	9	h^2	Loading
1. Otis-Lennon	920	563	690	759	723	726	636	560	603	745	863
2. CTBS Vocabulary	737	850	560	698	677	678	525	592	612	641	801
3. CTBS Reading	758	750	930	780	736	745	647	658	675	702	838
4. CTBS Spelling	606	570	591	890	666	687	651	719	705	524	724
5. CTBS Capitalization	585	535	584	611	850	536	621	628	635	550	742
6. CTBS Punctuation	581	534	569	584	677	850	610	636	636	539	734
7. CTBS Usage	684	684	688	628	604	615	850	607	604	660	812
8. CTBS Math Concepts	727	620	664	520	583	574	606	840	328	648	805
9. CTBS Math Problems	647	549	584	475	520	519	558	732	800	528	727
Total										5537	

[a] Reliabilities of the tests are given as the diagonal elements. Above the diagonal are the reliabilities of difference scores and below the diagonal are the correlations.

[b] Decimal is omitted.

Table 9

Correlations among Tests, Reliabilities, Reliabilities of Difference Scores, Communalities and Factor-Loadings for Grade Seven Saskatchewan Sample in 1978[a,b]

Tests	1	2	3	4	5	6	7	8	9	h^2	Loading
1. Otis-Lennon	920	479	590	730	673	633	511	551	532	804	897
2. CTBS Vocabulary	789	860	442	674	660	628	486	613	595	662	814
3. CTBS Reading	805	803	920	736	695	663	551	662	623	729	854
4. CTBS Spelling	629	601	621	880	618	554	569	713	637	560	748
5. CTBS Capitalization	648	573	623	647	850	402	522	599	569	609	780
6. CTBS Punctuation	687	610	659	697	749	850	431	580	541	684	827
7. CTBS Usage	693	650	666	606	613	675	780	554	527	606	779
8. CTBS Math Concepts	755	638	675	547	638	655	596	860	338	661	813
9. CTBS Math Problems	637	506	549	477	524	553	493	698	740	465	682
Total										5781	

[a] Reliabilities of the tests are given as the diagonal elements. Above the diagonal are the reliabilities of difference scores and below the diagonal are the correlations.

[b] Decimal is omitted.